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Bittner

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(54) **FREE COOLING CASCADE ARRANGEMENT FOR REFRIGERATION SYSTEM**

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(51) **Int. Cl.**
F25B 5/02 (2006.01)
F25B 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***F25B 7/00*** (2013.01); *F25B 2339/047* (2013.01); *F25B 2400/22* (2013.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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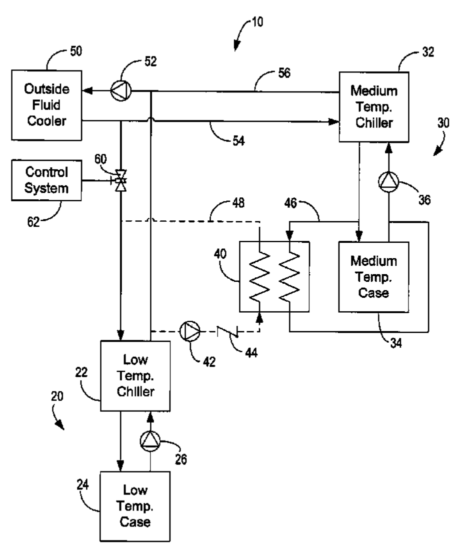
(57) **ABSTRACT**

A refrigeration system includes a medium temperature subsystem circulating a coolant in a closed loop between at least one medium temperature chiller and at least one medium temperature load and at least one cascade heat exchanger, and a low temperature subsystem circulating a coolant in a closed loop between at least one low temperature heat exchanger and at least one low temperature load. A cooling circuit is provided for circulating a coolant and includes a first pump and a second pump and a fluid cooler and a valve, and interfaces with the medium temperature chiller and the low temperature chiller. The valve is movable to a closed position to define a first flow path and a second flow path, where the first flow path includes the first pump and the medium temperature chiller and fluid cooler, and the second flow path including the second pump and the low temperature heat exchanger and the cascade heat exchanger.

26 Claims, 6 Drawing Sheets



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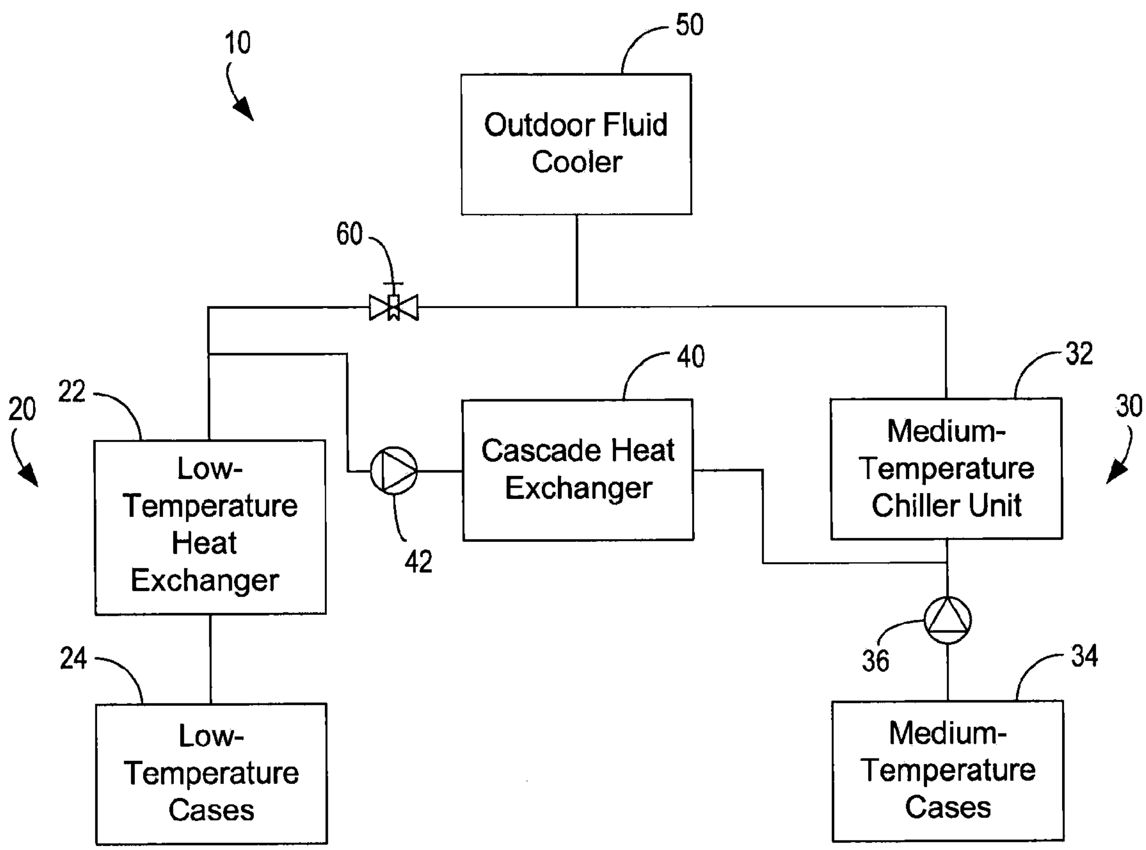

10
50
Outdoor Fluid Cooler
60
40
Cascade Heat Exchanger
32
Medium-Temperature Chiller Unit
30
20
22
Low-Temperature Heat Exchanger
42
36
24
34
Low-Temperature Cases
Medium-Temperature Cases

FIG. 1

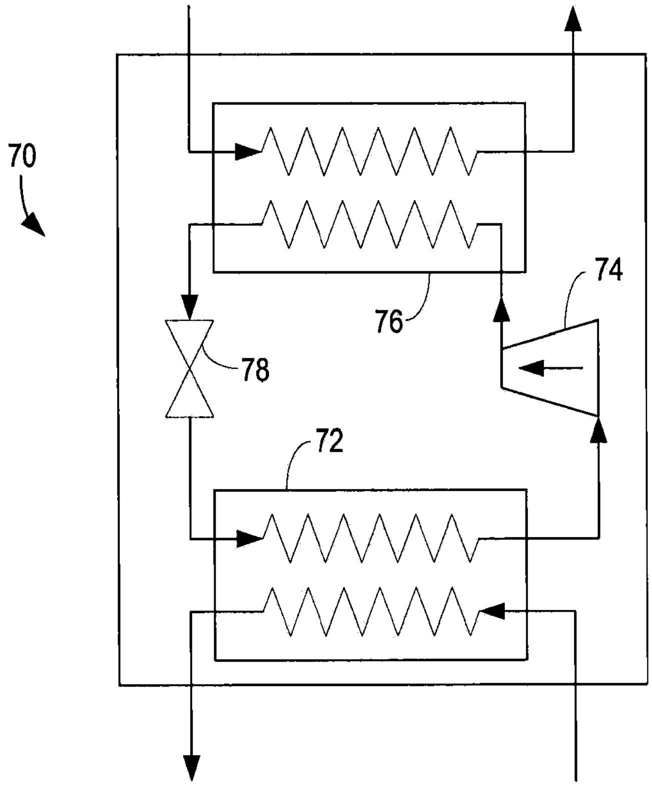

70
74
76
78
72

FIG. 2

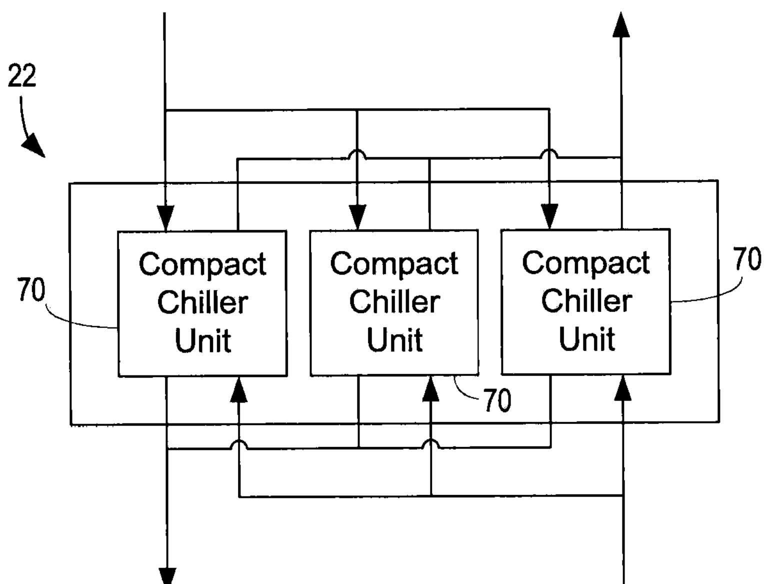
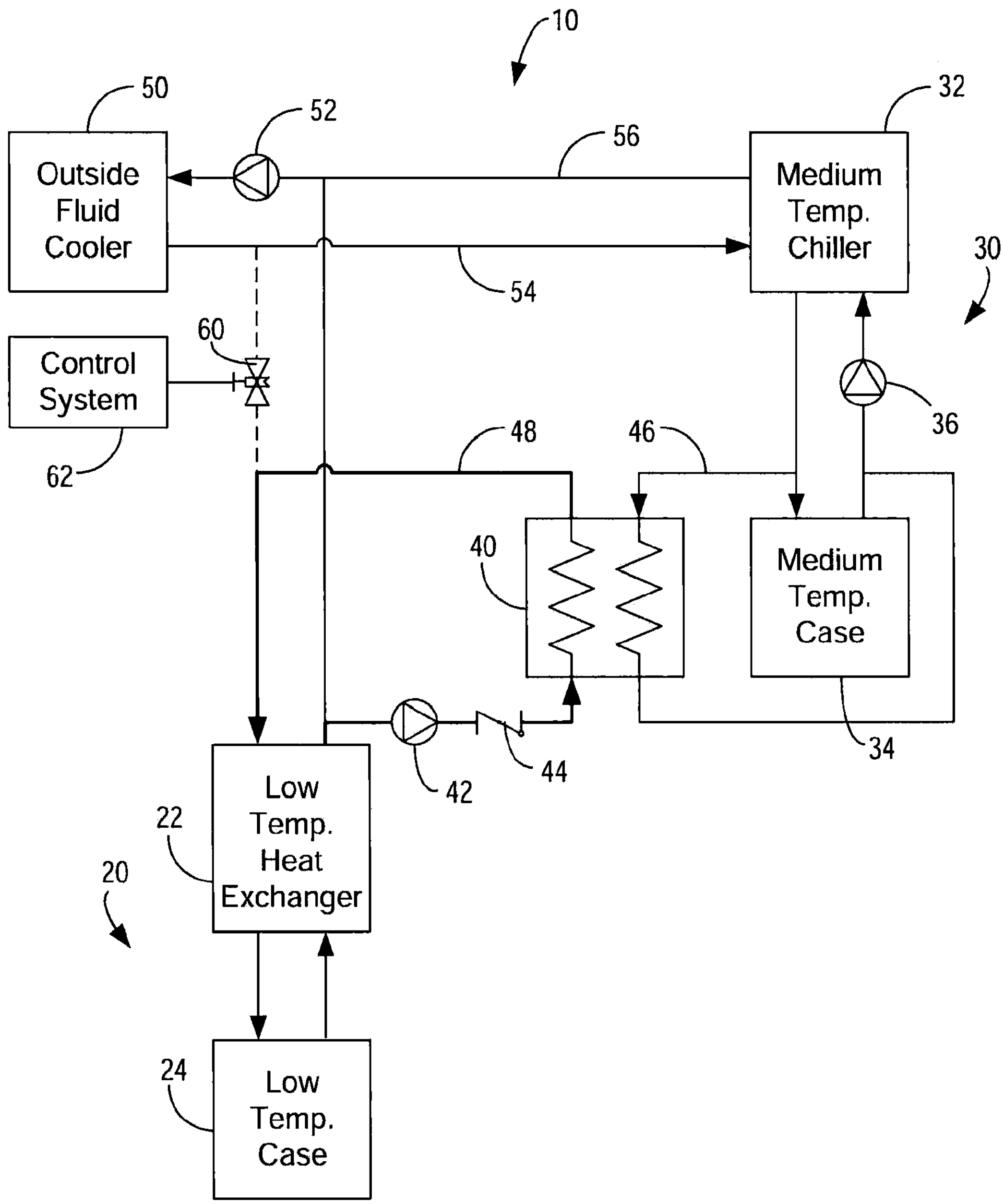

22
Compact Chiller Unit
Compact Chiller Unit
Compact Chiller Unit
70
70
70
70

FIG. 3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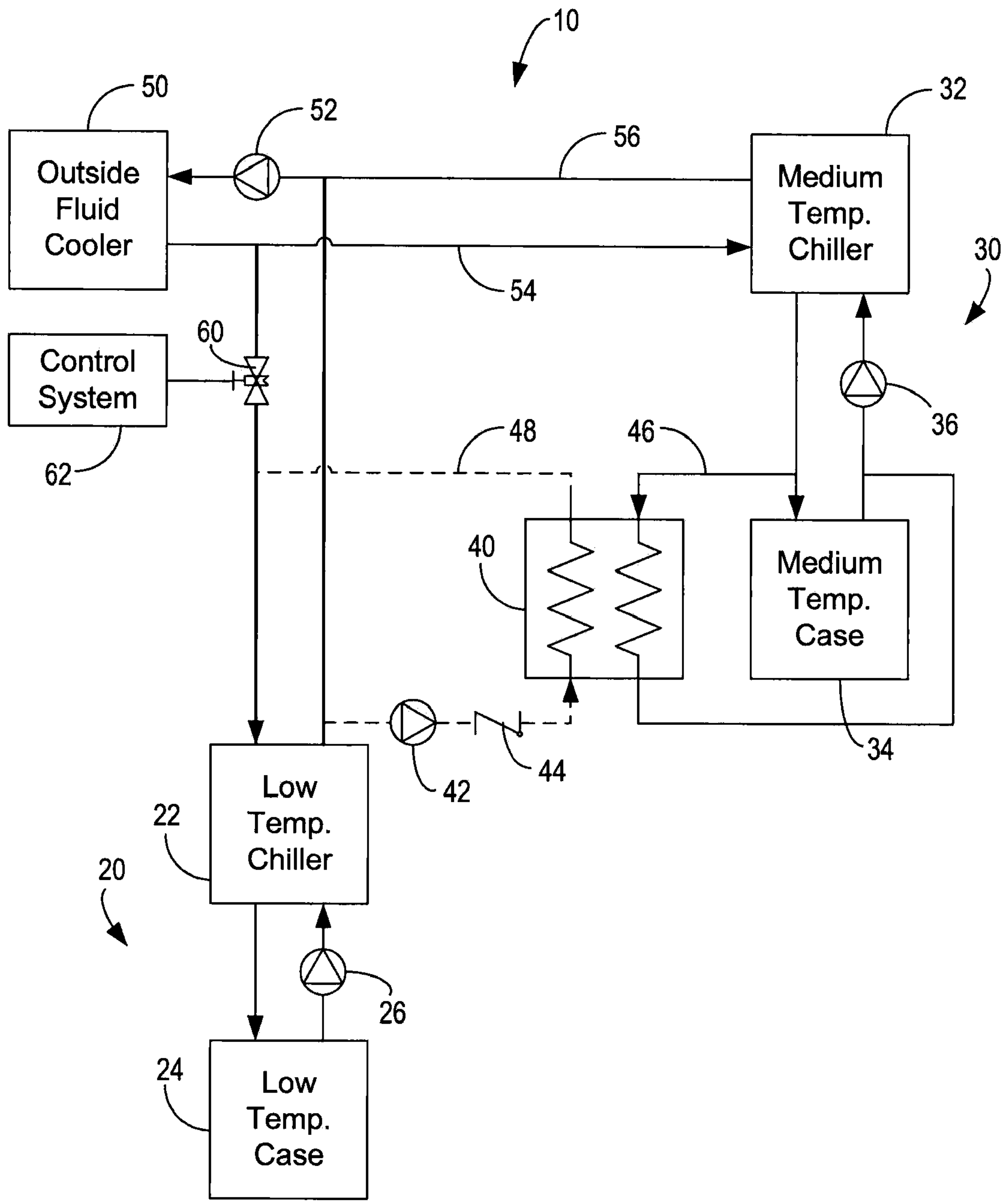
50
52
56
32
Outside Fluid Cooler
Medium Temp. Chiller
54
30
60
Control System
36
62
48
46
40
Medium Temp. Case
42
44
34
22
Low Temp. Heat Exchanger
20
24
Low Temp. Case

FIG. 4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32
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Medium Temp. Chiller
30
54
60
Control System
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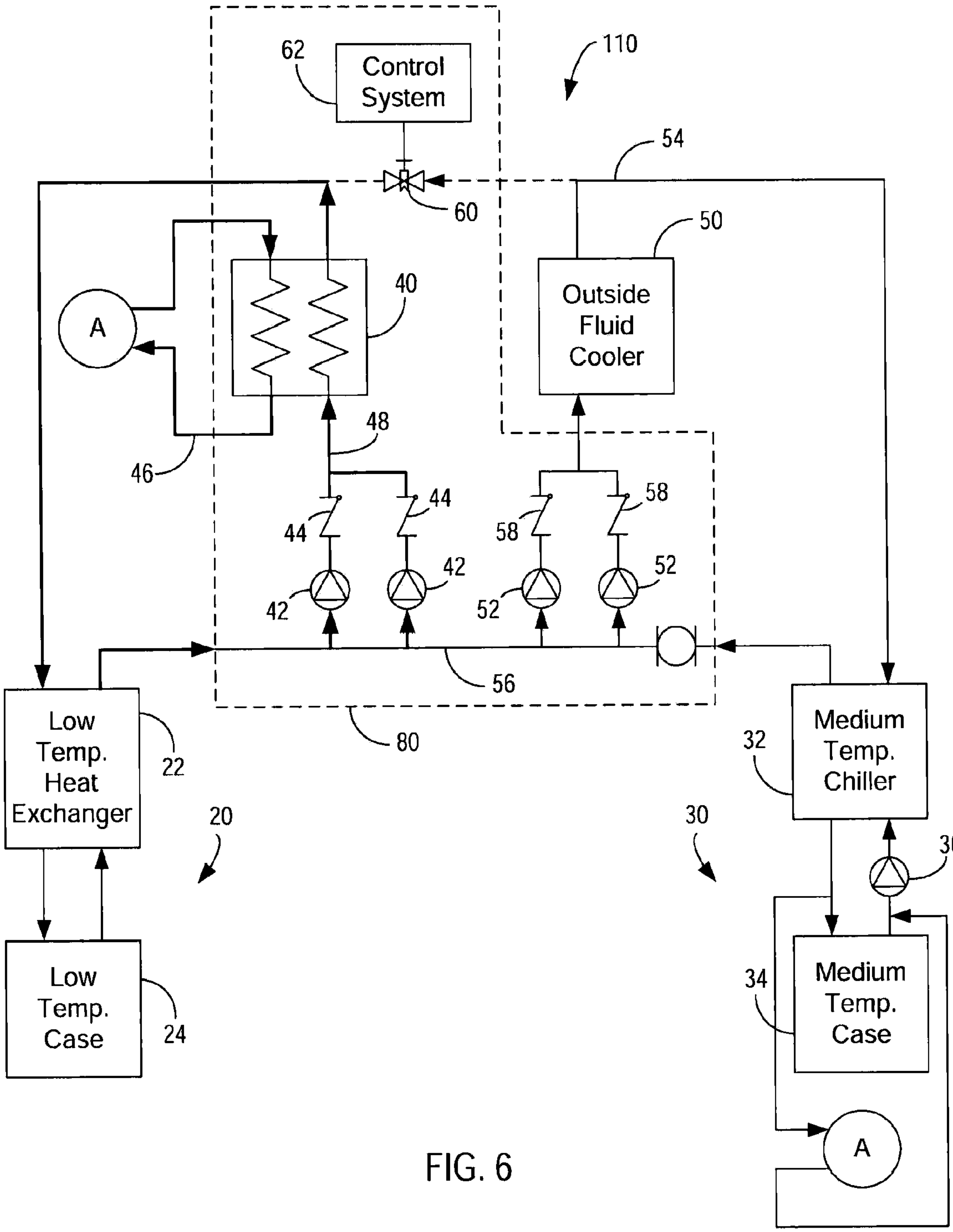
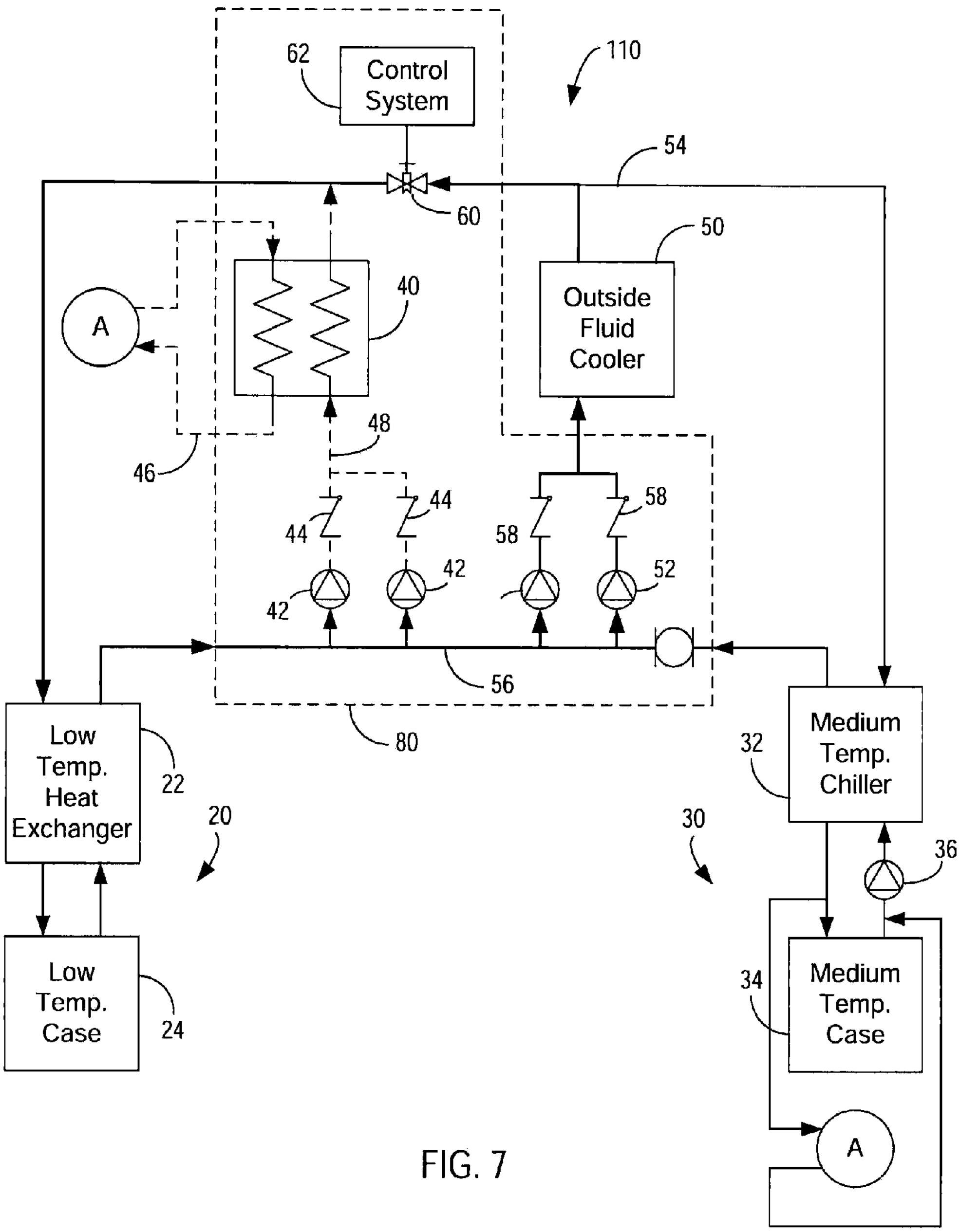
Medium Temp. Case
34
42
44
22
Low Temp. Chiller
20
26
24
Low Temp. Case

FIG. 5



110
62
Control System
54
60
50
Outside Fluid Cooler
40
A
48
46
44
44
58
58
42
42
52
52
56
80
Low Temp. Heat Exchanger
22
Medium Temp. Chiller
32
20
30
36
Low Temp. Case
24
Medium Temp. Case
34
A

FIG. 6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Control System
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58
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42
52
42
56
80
Low Temp. Heat Exchanger
22
20
Medium Temp. Chiller
32
30
36
Low Temp. Case
24
34
Medium Temp. Case
A

FIG. 7

FREE COOLING CASCADE ARRANGEMENT FOR REFRIGERATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of priority as a continuation-in-part of U.S. patent application Ser. No. 12/107,644 titled "Free Cooling Cascade Arrangement For Refrigeration System" filed on Apr. 22, 2008, the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND

The present invention relates to a refrigeration system with a low temperature portion and a medium temperature portion. The present invention relates more particularly to a refrigeration system where the low temperature portion may receive condenser cooling from refrigerant in the medium temperature portion in a cascade arrangement, or may share condenser cooling directly with the medium temperature system.

Refrigeration systems typically include a refrigerant that circulates through a series of components in a closed system to maintain a cold region (e.g., a region with a temperature below the temperature of the surroundings). One exemplary refrigeration system is a vapor refrigeration system including a compressor. Such a refrigeration system may be used, for example, to maintain a desired temperature within a temperature controlled storage device, such as a refrigerated display case, coolers, freezers, etc. The refrigeration systems may have a first portion with equipment intended to maintain a first temperature (such as a low temperature) and a second temperature (such as a medium temperature). The refrigerant in the low temperature portion and the refrigerant in the medium temperature portion are condensed in condensers which require a source of a coolant.

If the outside temperature is cold enough, an outdoor heat exchanger such as a cooling tower or a fluid cooler may be used as a part of the refrigeration system to provide a source of cooling for the condensors. Such an arrangement is often called a "free cooling" arrangement because the system does not need to operate an additional compressor. However, if the exterior air is not sufficiently cold, an exterior heat exchanger may not provide sufficient cooling for some systems.

SUMMARY

One embodiment of the invention relates to a refrigeration system, including medium temperature compact chiller units arranged in parallel and configured to cool a medium temperature liquid coolant for circulation to medium temperature refrigerated display cases, and low temperature heat exchangers arranged in parallel and configured to cool a low temperature coolant or refrigerant for circulation to low temperature refrigerated display cases. A coolant supply header supplies a coolant to the medium temperature compact chiller units and the low temperature heat exchanger. A coolant suction header receives the coolant from the medium temperature compact chiller units and the low temperature heat exchanger. A fluid cooler cools the coolant in the coolant supply header. A cascade heat exchanger receives a supply of the medium temperature liquid coolant from the medium temperature compact chiller units. A pump is configured to pump the coolant from the coolant suction header to the coolant supply header and through the fluid cooler. Another pump is configured to pump the coolant from the coolant suction header to the coolant supply header and through the cascade heat exchanger. A valve on the coolant supply header between the low temperature heat exchanger and the medium temperature compact chiller units is movable to a closed position to define one cooling flow path comprising the first pump and the fluid cooler and the medium temperature modular chiller units, and another cooling flow path comprising the second pump and the cascade heat exchanger and the low temperature heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram of a refrigeration system according to an exemplary including an outside fluid cooler that may selectively provide cooling for a low temperature refrigeration loop.

FIG. **2** is a block diagram of chiller unit of the system of FIG. **1** according to one exemplary embodiment.

FIG. **3** is a block diagram of an assembly of the chiller units of FIG. **2** arranged in parallel.

FIG. **4** is a block diagram of a refrigeration system according to one exemplary embodiment in a normal or cascade cooling arrangement.

FIG. **5** is a block diagram of the refrigeration system of FIG. **4** in a free cooling arrangement.

FIG. **6** is a block diagram of a refrigeration system according to another exemplary embodiment in a normal or cascade cooling arrangement.

FIG. **7** is a block diagram of the refrigeration system of FIG. **6** in a free cooling arrangement.

DETAILED DESCRIPTION

Referring to FIG. **1**, a refrigeration system **10** is shown according to an exemplary embodiment. Refrigeration systems **10** typically include a refrigerant (e.g., a vapor compression/expansion type refrigerant, etc.) that circulates through a series of components in a closed system to maintain a cold region (e.g., a region with a temperature below the temperature of the surroundings). The refrigeration system **10** of FIG. **1** includes several subsystems or loops.

A first or low temperature subsystem **20** includes a low temperature heat exchanger **22** (e.g. condenser, etc.), and one or more low temperature cases **24** (e.g., refrigerated display cases, etc.). A low temperature coolant or refrigerant (e.g. carbon dioxide, ammonia, etc.) may be circulated between heat exchanger **22** and cases **24** in a closed loop cooling or refrigeration circuit to maintain cases **24** at a relatively low temperature.

A second or medium temperature subsystem **30** includes a medium temperature chiller **32**, one or more medium temperature cases **34** (e.g., refrigerated display cases), and a pump **36**. Pump **36** circulates a medium temperature liquid coolant (e.g., propylene glycol at approximately 20° F.) between chiller **32** and cases **34** to maintain cases **34** at a relatively medium temperature.

Medium temperature chiller **32** removes heat energy from medium temperature cases **34** and, in turn, gives the heat energy up to a heat exchanger, such as an outdoor fluid cooler **50** or outdoor cooling tower to be dissipated to the exterior environment. Medium temperature chiller **32** is further coupled to a cascade heat exchanger **40** to provide a source of coolant to the cascade heat exchanger.

Low temperature heat exchanger **22** receives heat energy from a low temperature cases **24** (e.g. directly from a liquid coolant that has been warmed in cases **24**, or from a refrigerant circulating in a vapor-compression, direct-expansion refrigeration loop between an evaporator in cases **24**, a compressor (not shown) and heat exchanger **22** (which may act as a condenser). Low temperature heat exchanger **22** may be coupled to either cascade heat exchanger **40** or fluid cooler **50**. A valve **60** that is provided between low temperature subsystem **20** and fluid cooler **50**, and a pump **42** provided between low temperature subsystem **20** and cascade heat exchanger **40**, serve to determine to which component the low temperature heat exchanger **22** is coupled. In a normal operation or cascade mode, valve **60** is closed and pump **42** is activated, coupling low temperature heat exchanger **22** to cascade heat exchanger **40**. However, if the exterior temperature is low enough, system **10** may enter a free cooling mode. In a free cooling mode, pump **42** is turned off and valve **60** is opened, coupling low temperature heat exchanger **22** to fluid cooler **50**.

The terms “low temperature” and “medium temperature” are used herein for convenience to differentiate between two subsystems of refrigeration system **10**. Low temperature system **20** maintains one or more cases **24** such as freezer display cases or other cooled areas at a temperature lower than the ambient temperature. Medium temperature system **30** maintains one or more cases **34** such as refrigerator cases or other cooled areas at a temperature lower than the ambient temperature but higher than low temperature cases **24**. According to one exemplary embodiment, low temperature cases **24** may be maintained at a temperature of approximately minus (−) 20° F. and medium temperature cases **34** may be maintained at a temperature of approximately 20° F. Although only two subsystems are shown in the exemplary embodiments described herein, according to other exemplary refrigeration system **10** may include more subsystems that may be selectively cooled in a cascade arrangement or in a free cooling arrangement.

One exemplary chiller unit **70** is shown in FIG. **2** and may be of a type used for a medium temperature chiller **32**. Chiller unit **70** includes a refrigerant that is circulated through a vapor-compression refrigeration cycle including a first heat exchanger **72**, a compressor **74**, a second heat exchanger **76**, and an expansion valve **78**. In the first heat exchanger **72**, the refrigerant absorbs heat from an associated display case(s) or other cooled area via a coolant circulated by a pump (e.g. pump **36** for medium temperature cases, etc.). In the second heat exchanger **76** (e.g. condenser, etc.), the refrigerant gives up heat to a second coolant. The second coolant, in turn, gives up heat to the exterior environment. Various elements of the chiller unit **70** may be combined. For example, heat exchangers **72** and **76** may comprise a single device in one exemplary chiller unit **70**.

According to one exemplary embodiment, chiller unit **70** is a compact modular chiller unit. As shown in FIG. **3**, medium temperature chiller **32** may include a multitude of chiller units **70** arranged in parallel. The number of chiller units **70** may be varied to accommodate various cooling loads associated with a particular system.

Referring now to FIGS. **4** and **5**, a refrigeration system **10** is shown according to one exemplary embodiment in a cascade mode (FIG. **4**) and a free cooling mode (FIG. **5**). Refrigeration system **10** includes a low temperature subsystem **20**, a medium temperature subsystem **30**, a cascade heat exchanger **40**, a fluid cooler **50**, and a valve **60** that selectively couples low temperature subsystem **20** to fluid cooler **50**.

Fluid cooler **50** is shown to be provided outside a building where it is exposed to the outside air (e.g. at ambient temperature, etc.). Fluid cooler **50** uses the outside air to cool a coolant (e.g. a condenser coolant such as water, etc.) that flows through a condenser cooling circuit for refrigeration system **10**. Fluid cooler **50** is coupled to a condenser coolant supply header **54** and a condenser coolant suction header **56**. Flow through fluid cooler **50** is provided by a pump **52** located, for example, in-line with suction header **56**. Medium temperature subsystem **30** is cooled by fluid cooler **50** in all modes and fluid is circulated through medium temperature chiller **32** via supply header **54** and suction header **56**. Low temperature subsystem **20** is likewise coupled to supply header **54** and suction header **56** with valve **60** provided between low temperature heat exchanger **22** and fluid cooler **50**.

Cascade heat exchanger **40** is coupled to both low temperature subsystem **20** and medium temperature subsystem **30**. According to an exemplary embodiment, one side of cascade heat exchanger **40** is connected to a first loop **46** that is coupled in parallel with medium temperature cases **34** to medium temperature chiller **32** (e.g., on the first heat exchanger **72** side of chiller **32**). A second side of exchanger **40** is connected to a second loop **48** that is coupled to low temperature heat exchanger **22** opposite of low temperature cases **24**. A pump **42** is provided to circulate fluid through second loop **48** and a check valve **44**. Fluid in first loop **46** is circulated by pump **36** of medium temperature subsystem **30**.

Referring to FIG. **4**, in a normal operation or cascade mode, valve **60** is moved to a closed position that defines two flow paths, and pump **42** is activated. In the first flow path, low temperature heat exchanger **22** is coupled to cascade heat exchanger **40** and pump **42** to provide a cascade condenser cooling loop for the low temperature system **20**. In the second flow path, medium temperature chiller **32** is coupled to fluid cooler **50** and pump **52** to provide a condenser cooling loop for the medium temperature chillers. While valve **60** is closed, isolating low temperature heat exchanger **22** from supply header **54**, a small amount of fluid may still mix with the fluid in suction header **56** (e.g. fluid flowing from medium temperature chiller **32** to condenser pumps **52**). Fluid in second loop **48** passes through low temperature heat exchanger **22** and is heated, carrying heat energy absorbed from low temperature cases **24** to cascade heat exchanger **40**. In heat exchanger **40** fluid in second loop **48** thus heats fluid in first loop **46**. Fluid in first loop **46** joins heated fluid from medium temperature cases **34** and is cooled by medium temperature chiller **32** before returning to cascade heat exchanger **40**.

If the outside temperature is sufficiently cold (e.g., below 60° F.), refrigeration system **10** may be converted to a “free cooling” mode as shown in FIG. **5**. In the free-cooling mode valve **60** is moved to the open position to define a third flow path that provides condenser cooling for both the medium temperature chillers **32** and the low temperature heat exchangers **22** from fluid cooler **50** and bypasses the cascade heat exchanger **40** by turning pump **42** off and any back flow through second loop **48** is halted by check valve **44**. In the third flow path, pumps **52** circulate the fluid (e.g. condenser coolant) through the fluid cooler **50** and then to the heat exchanger **22** in the low temperature system **20** and to the condenser within the medium temperature chillers **32**. The fluid passes through low temperature heat exchanger **22** and is heated, carrying heat energy absorbed from low temperature system **20** to suction header **56**. Pump **52** then pumps the fluid to fluid cooler **50** where it is cooled by the outside air before returning in a condensing loop to supply header **54** and then to low temperature heat exchanger **22**. Bypassing cascade heat exchanger **40** places a smaller load on medium temperature chillers **32** and takes advantage of the relatively low-cost cooling provided by outside fluid cooler **50**.

The operation of valve **60** and pump **42** is controlled by a control system **62**. Control system monitors the outside conditions (e.g., temperature, relative humidity, etc.) and determines whether refrigeration system **10** functions in a cascade mode or a free cooling mode by operating valve **60** and pump **42**.

Referring now to FIGS. **6** and **7**, a refrigeration system **110** is shown according to another exemplary embodiment in a cascade mode (FIG. **6**) and a free cooling mode (FIG. **7**). Refrigeration system **110** may be, for example, an existing system that is retrofitted to incorporate the advantages described above. Refrigeration system **110** includes a low temperature subsystem **20**, a medium temperature subsystem **30**, a fluid cooler **50**, and a pump station **80**. Pump station **80** includes a cascade heat exchanger **40**, cascade pumps **42**, condenser pumps **52**, and a valve **60** that selectively couples low temperature subsystem **20** to fluid cooler **50** for operation in a free-cooling mode.

Fluid cooler **50** is typically provided outside a building (e.g. food retail outlet, etc.) where it is exposed to the outside air. Fluid cooler **50** uses the outside air to cool a coolant for refrigeration system **110**. Fluid cooler **50** is coupled to a common supply header **54** and a common suction header **56**. Flow through fluid cooler **50** is provided by a one or more condenser pumps **52**. As shown in FIGS. **6** and **7**, two or more condenser pump **52** and check valve **58** pairs may be arranged in parallel and be coupled to common suction header **56**. Medium temperature subsystem **30** is cooled by fluid cooler **50** in all modes and fluid passes through medium temperature chiller **32** via supply header **54** and suction header **56**. Low temperature subsystem **20** is likewise coupled to a condensing loop including supply header **54** and suction header **56** with valve **60** provided between low temperature heat exchanger **22** and fluid cooler **50**.

Cascade heat exchanger **40** is coupled to both low temperature subsystem **20** and medium temperature subsystem **30**. According to an exemplary embodiment, one side of heat exchanger **40** is connected to a first loop **46** that is coupled in parallel with medium temperature cases **34** to medium temperature chiller **32** (e.g., on the first heat exchanger **72** side of chiller **32**). A second side of cascade heat exchanger **40** is connected to a second loop **48** that is coupled to low temperature heat exchanger **22** which may serve as a condenser for condensing a refrigerant (e.g. carbon dioxide, ammonia, etc.) circulating in a closed loop vapor-compression, direct-expansion circuit in the low temperature subsystem **20** through low temperature cases **24**. Alternatively, heat exchanger **22** may be configured as a chiller (such as a chiller **70** as shown in FIG. **2**) to provide cooling to a liquid coolant (e.g. liquid carbon dioxide, etc.) circulating via a pump **26** in a loop of the low temperature subsystem **20** between heat exchanger **22** and cases **24** (see FIG. **5**). Cascade heat exchanger **40** includes one or more cascade pumps **42** to circulate fluid (e.g. water or other suitable coolant) through second loop **48** and check valve **44**. As shown in FIGS. **6** and **7**, two or more cascade pump **42** and check valve **44** pairs may be arranged in parallel and be coupled to common suction header **56**. According to the illustrated embodiment, fluid in first loop **46** is circulated by pump **36** of medium temperature subsystem **30**.

Referring to FIG. **6**, in a normal operation or cascade mode, valve **60** is closed and pumps **42** are activated, thus coupling low temperature heat exchanger **22** to cascade heat exchanger **40**. While valve **60** is closed, isolating low temperature heat exchanger **22** from supply header **54**, a small amount of fluid may still mix with the fluid in suction header **56** (e.g. fluid flowing from medium temperature chiller **32** to condenser pumps **52**). Fluid in second loop **48** passes through low temperature heat exchanger **22** and is heated, carrying heat energy absorbed from low temperature subsystem **20** to cascade heat exchanger **40**. In heat exchanger **40**, fluid in second loop **48** heats the fluid in first loop **46**. Fluid in first loop **46** joins heated fluid from medium temperature cases **34** and is cooled by medium temperature chiller **32** before returning to cascade heat exchanger **40**.

If the outside temperature is sufficiently cold (e.g., below 60° F. or other suitable temperature as determined by system operating requirements), refrigeration system **110** may be converted to a free cooling mode as shown in FIG. **7**. Valve **60** is opened, thus coupling low temperature heat exchanger **22** to fluid cooler **50**. Pumps **42** are turned off and any back flow through second loop **48** is halted by check valves **44**. Fluid passes through low temperature heat exchanger **22** and is heated, carrying heat energy absorbed from low temperature subsystem to suction header **56**. Pumps **52** then circulate the fluid to fluid cooler **50** where it is cooled by the outside air before returning in a condensing loop including supply header **56** and then to low temperature heat exchanger **22**. Bypassing cascade heat exchanger **40** places a smaller load on medium temperature chillers **32** and takes advantage of the relatively low-cost cooling provided by outside fluid cooler **50**.

The operation of valve **60** and pump **42** is controlled by a control system **62**. Control system monitors the outside conditions (e.g., temperature, relative humidity, etc.) and determines whether refrigeration system **110** functions in a cascade mode or a free cooling mode by operating valve **60** and pump **42**.

It is important to note that the construction and arrangement of the elements of the refrigeration system provided herein are illustrative only. Although only a few exemplary embodiments of the present invention(s) have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible in these embodiments (such as variations in features such as connecting structure, components, materials, sequences, capacities, shapes, dimensions, proportions and configurations of the modular elements of the system, without materially departing from the novel teachings and advantages of the invention(s). For example, any number of chiller units may be provided in parallel to cool the low temperature and medium temperature cases, or more subsystems may be included in the refrigeration system (e.g., a very cold subsystem or additional cold or medium subsystems). Further, it is readily apparent that variations and modifications of the refrigeration system and its components and elements may be provided in a wide variety of materials, types, shapes, sizes and performance characteristics. Accordingly, all such variations and modifications are intended to be within the scope of the invention(s).

What is claimed is:

1. A refrigeration system, comprising:

a plurality of medium temperature heat exchangers arranged in parallel and configured to cool a medium temperature coolant for circulation in a first closed loop between the medium temperature heat exchangers and a plurality of medium temperature refrigerated display cases;

a plurality of low temperature heat exchangers arranged in parallel and configured to cool a low temperature coolant for circulation in a second closed loop between the low temperature heat exchangers and a plurality of low temperature refrigerated display cases;

a condenser coolant supply header configured to supply a condenser coolant to the low and medium temperature heat exchangers;

a condenser coolant suction header configured to receive the condenser coolant from the low and medium temperature heat exchangers;

a fluid cooler configured to cool the condenser coolant in the condenser coolant supply header;

a cascade heat exchanger separate from the medium temperature heat exchangers and arranged in parallel with the medium temperature refrigerated display cases along the first closed loop such that the medium temperature heat exchangers provide a supply of the medium temperature coolant to both the cascade heat exchanger and the medium temperature refrigerated display cases in parallel;

at least one first pump configured to pump the condenser coolant from the condenser coolant suction header to the coolant supply header and through the fluid cooler;

at least one second pump configured to pump the condenser coolant from the coolant suction header to the condenser coolant supply header and through the cascade heat exchanger;

a valve disposed on the condenser coolant supply header between the low temperature heat exchangers and the fluid cooler, the valve movable to a closed position to define a first cooling flow path comprising the first pump and the fluid cooler and the medium temperature heat exchangers, and a second cooling flow path comprising the second pump and the cascade heat exchanger and the low temperature heat exchangers;

wherein the cascade heat exchanger is configured to receive both the coolant from the low temperature heat exchangers and the supply of the medium temperature coolant from the medium temperature heat exchangers when the valve is closed and to cool the coolant from the low temperature heat exchangers using the supply of the medium temperature coolant from the medium temperature heat exchangers.

2. The refrigeration system of claim **1** wherein the medium temperature heat exchanger comprises a chiller for cooling a medium temperature liquid coolant circulating to the medium temperature refrigerated display cases.

3. The refrigeration system of claim **1** wherein the low temperature heat exchanger comprises a chiller for cooling a low temperature liquid coolant circulating to the low temperature refrigerated display cases.

4. The refrigeration system of claim **3** wherein the low temperature liquid coolant comprises liquid carbon dioxide.

5. The refrigeration system of claim **1** wherein the low temperature heat exchanger comprises a condenser and the low temperature coolant comprises a refrigerant.

6. The refrigeration system of claim **5** wherein the refrigerant comprises carbon dioxide or ammonia.

7. The refrigeration system of claim **1** wherein the first cooling flow path and the second cooling flow path share a common suction header between the first pump and the second pump.

8. The refrigeration system of claim **7** wherein the valve is movable to an open position to define a third flow path comprising the fluid cooler and the medium temperature heat exchangers and the low temperature heat exchangers.

9. The refrigeration system of claim **1** wherein the fluid cooler is an outdoor fluid cooler configured to use air at an ambient temperature to cool the coolant.

10. The refrigeration system of claim **9** further comprising a control system operable to close the valve when the ambient temperature is above a predetermined level, and to open the valve when the ambient temperature is below the predetermined level.

11. The refrigeration system of claim **8** wherein the second pump is turned on when the valve is in the closed position to circulate the coolant through the second flow path, and the second pump is turned off when the valve is open the open position so that the first pump circulates the coolant through the third flow path.

12. A refrigeration system, comprising:

at least one medium temperature chiller for cooling a medium temperature coolant circulated in a first closed loop between the medium temperature chiller and at least one medium temperature refrigerated display case;

at least one low temperature heat exchanger for cooling a low temperature coolant circulated in a second closed loop between the low temperature heat exchanger and at least one low temperature refrigerated display case;

a condenser coolant supply header configured to supply a condenser coolant to the medium temperature chiller and to the low temperature heat exchanger;

a condenser coolant suction header configured to receive the condenser coolant from the medium temperature chiller and from the low temperature heat exchanger;

a fluid cooler configured to receive and cool the condenser coolant;

a cascade heat exchanger separate from the medium temperature chiller and arranged in parallel with the medium temperature refrigerated display case along the first closed loop such that the medium temperature chiller provides a supply of the medium temperature coolant to both the cascade heat exchanger and the medium temperature refrigerated display case in parallel;

at least one condenser coolant pump configured to pump the condenser coolant from the condenser coolant suction header to the condenser coolant supply header and through the fluid cooler;

at least one cascade pump configured to pump the condenser coolant from the condenser coolant suction header to the condenser coolant supply header and through the cascade heat exchanger; and

a valve movable to a closed position to define a first cooling flow path comprising the condenser pump and the fluid cooler and the medium temperature chiller, and a second cooling flow path comprising the cascade pump and the cascade heat exchanger and the low temperature heat exchanger;

wherein the cascade heat exchanger is configured to receive both the coolant from the low temperature heat exchanger and the supply of the medium temperature coolant from the medium temperature chiller when the valve is closed and to cool the coolant from the low temperature heat exchanger using the supply of the medium temperature coolant from the medium temperature chiller.

13. The refrigeration system of claim **12** wherein the first cooling flow path and the second cooling flow path share a common suction header between the condenser pump and the cascade pump.

14. The refrigeration system of claim **13** wherein the valve is movable to an open position to define a third flow path comprising the fluid cooler and the medium temperature chiller and the low temperature heat exchanger.

15. The refrigeration system of claim **12** wherein the fluid cooler is an outdoor fluid cooler configured to use air at an ambient temperature to cool the coolant.

16. The refrigeration system of claim **15** further comprising a control system operable to close the valve when the ambient temperature is above a predetermined level, and to open the valve when the ambient temperature is below the predetermined level.

17. The refrigeration system of claim **14** wherein the cascade pump is turned on when the valve is in the closed position to circulate the coolant through the second flow path, and the second pump is turned off when the valve is open the open position so that the first pump circulates the coolant through the third flow path.

18. A refrigeration system, comprising:

a medium temperature subsystem circulating a medium temperature coolant in a first closed loop between at least one medium temperature heat exchanger and at least one medium temperature load and at least one cascade heat exchanger separate from the medium temperature heat exchanger and arranged in parallel with the medium temperature load along the first closed loop such that the medium temperature heat exchanger provides the medium temperature coolant to both the cascade heat exchanger and the medium temperature load in parallel;

a low temperature subsystem circulating a low temperature coolant in a second closed loop between at least one low temperature heat exchanger and at least one low temperature load;

a condenser cooling circuit for circulating a condenser coolant, the condenser cooling circuit having a first pump and a second pump and a fluid cooler and a valve, and interfacing with the medium temperature heat exchanger and the low temperature heat exchanger;

wherein the valve is movable to a closed position defining a first flow path and a second flow path, the first flow path including the first pump and the medium temperature heat exchanger and fluid cooler and the second flow path including the second pump and the low temperature heat exchanger and the cascade heat exchanger;

wherein the cascade heat exchanger is configured to receive both the coolant from the low temperature heat exchanger and the medium temperature coolant from the medium temperature heat exchanger when the valve is closed and to cool the coolant from the low temperature heat exchanger using the medium temperature coolant from the medium temperature heat exchanger.

19. The refrigeration system of claim **18** wherein the medium temperature heat exchanger comprises a chiller for cooling a medium temperature liquid coolant circulating to the medium temperature load.

20. The refrigeration system of claim **18** wherein the low temperature heat exchanger comprises a chiller for cooling a low temperature liquid coolant circulating to the low temperature load.

21. The refrigeration system of claim **20** wherein the low temperature liquid coolant comprises liquid carbon dioxide.

22. The refrigeration system of claim **18** wherein the low temperature heat exchanger comprises a condenser and the low temperature coolant comprises a refrigerant.

23. The refrigeration system of claim **22** wherein the refrigerant comprises carbon dioxide or ammonia.

24. The refrigeration system of claim **18** wherein the valve is movable to an open position to define a third flow path comprising the fluid cooler and the medium temperature heat exchanger and the low temperature heat exchanger.

25. The refrigeration system of claim **24** further comprising a control system operable to actuate the valve between the open position and the closed position based on a signal representative of an air temperature proximate the fluid cooler.

26. The refrigeration system of claim **24** wherein the valve is disposed in the cooling circuit between the low temperature chiller and the fluid cooler.

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